Fast landmark matching algorithm using moving guide-line image

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Abstract: Landmark matching is one of an important algorithm for navigation of satellite images. This paper proposes a fast landmark matching algorithm using a MGLI (Moving Guide-Line Image). For searching the matched point between the landmark chip and a part of image, correlation matrix is used generally, but the full-sized correlation matrix has a drawback requiring plenty of time for matching point calculation.

MGLI includes thick lines for fast calculation of correlation matrix. In the MGLI, width of the thick lines should be determined by satellite position changes and navigation error range. For the fast landmark matching, the MGLI provides guided line for a landmark chip we want to match, so that the proposed method should reduce candidate areas for correlation matrix calculation. This paper will show how much time is reduced in the proposed fast landmark matching algorithm compared to general ones.

Keywords: Landmark, Landmark Matching, Perspective Plane Image, GSHHS, Fast Landmark Matching, and Correlation Matrix.

1. Introduction

Navigation is a process to allocate latitude and longitude information in satellite images. Landmarks are an important fact for navigation, so accurate and fast landmark calculation algorithms are also needed [1].

To calculate the similarity between two data, a correlation is generally used. But correlation has a drawback in that if the data size is large, plenty of time is required for the calculation.

This paper shows a fast landmark matching algorithm that reduces the number of calculations of correlation, using a MGLI.

This paper suggests two algorithms for the fast calculation of correlation. The first one is based on the calculative information of a landmark. It is easy to realize, but it has some faults because a satellite image is not generated by a calculative algorithm. The other algorithm is based on one of the results of the processing of the satellite image. So it has some inaccuracies but is actually easy to apply. Chap. 3 explains two proposed algorithms and chap. 4 proofs their merits by software simulation.

2. Basic Theories

1) Global Perspective Plane Image Generation using the GSHHS

Geographic information at the projection point, global physical constants, and the WGS (World Geodetic System) make a perspective global image. We make a perspective global image of the COMS (Communication, Ocean, and Meteorological Satellite) using the global physical constants in Table.1, the intermediate data of the GSHHS, and the WGS 84 model [2,3].

Table1. Items for generation of global perspective plan image

Items	Values	
Distance from center of the global to projection point	42,164 Km	
Latitude and longitude at the direct below point of projection	116°E 0°N	
Radius of the global	Long	6378.137 Km
	Short	6356.752 Km

2) Geographical Information determination using a landmark

Fig.1. is a perspective global image at the COMS's position, and Fig.2. shows the process of geographical information determination using a landmark. The vertex-connected landmark chip should be extracted from the perspective global image as in Fig.1.

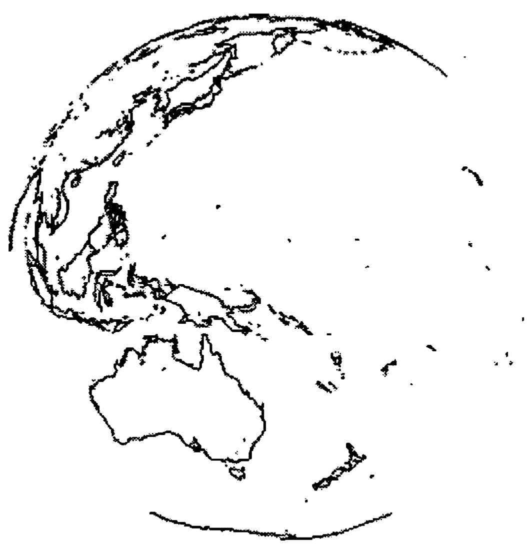


Fig.1. Perspective Global Image at the COMS' Position

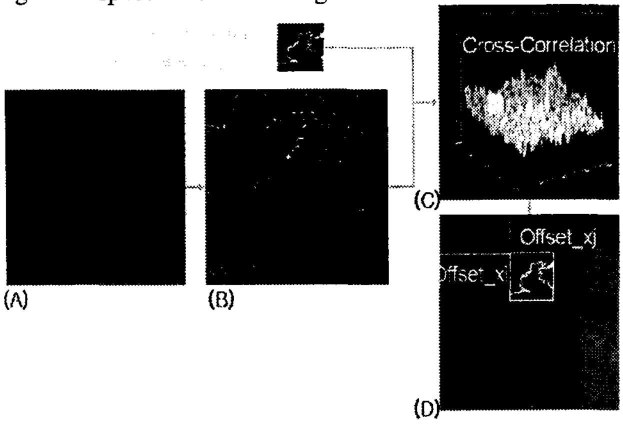


Fig.2. Process of geographical information determination using landmark

First, some part of image (A) is extracted from a whole satellite image. The extracted image is processed by the Sobel mask for detection of edges (B). To find the matched point of the vertex-connected landmark chip and the Sobel masked image, a correlation matrix calculation is needed (C). The position - equal to offset Fig.2. (D) - that has the maximum value of the correlation matrix is the matched point between the vertex-connected landmark chip and the Sobel masked image.

3. Fast Landmark Matching Algorithms

1) Guide-Line using Perspective Plane Image

To search the match point, the calculation of the correlation between the vertex-connected landmark chip and the Sobel masked image is needed and the calculation requires plenty of time. In conventional calculations of correlation, all of the area is considered a candidate point for the matched point, so that a lot of time is required for the calculation of a correlation matrix as in Fig.3.(A)[1].

Fig.3.(B) shows a proposed algorithm for fast landmark matching. The thick gray guide-line in the Fig.3. (B) is made from the perspective plane, and only the gray-colored points are joined in calculation of the correlation matrix. The thick gray guide-line helps to reduce the calculation time on a large scale.

2) Moving Guide-Line Image : MGLI

The guide-line, using the perspective plane image, can be made quickly but can't apply the images from GOES because the images have errors, as in Fig.4[4]. Fig.4 (A) is a part of the satellite image and (B) is a part of the perspective plane image, and the two images are extracted from the same position for each whole image. The maximum difference between the two images is more than 40 pixels.

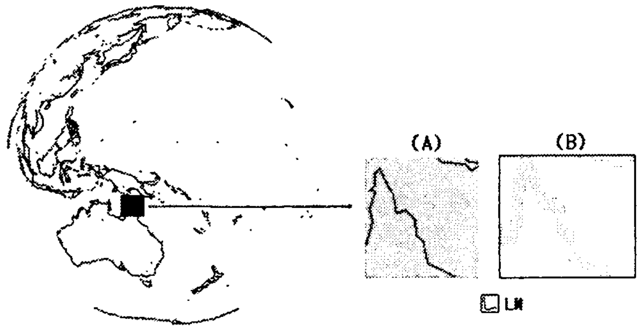
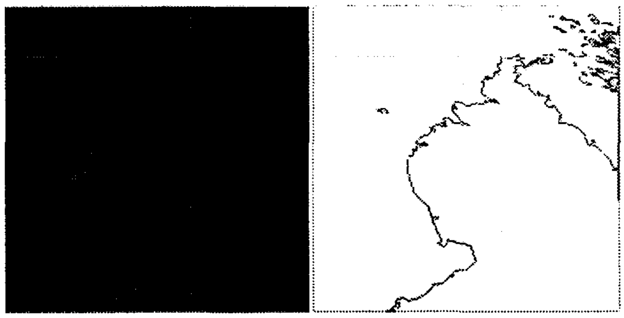


Fig.3. Comparison of landmark matching algorithms (A) Conventional (B) proposed



(A) (B)

Fig.4. Satellite image (A) vs. perspective plane image (B) on a same latitude and longitude

To overcome the drawback of position error, we make the guide-line from the Sobel masked image, not from the perspective plane image. Fig.5. shows the proposed fast landmark matching algorithm.

The perspective plane image (A) is used only to make the landmark chip (B). First, part of the perspective plane image is extracted to make the landmark chip. Next, part of the satellite image (D) is used to allocate geographic information extracts from the satellite image (C). For the edge detection, a Sobel mask is applied (E) to the part of the satellite image, and a MGLI (F) is made, using the Sobel masked image. Last, the point is matched between the Sobel masked image (E) and the landmark chip (B), using the MGLI (F).

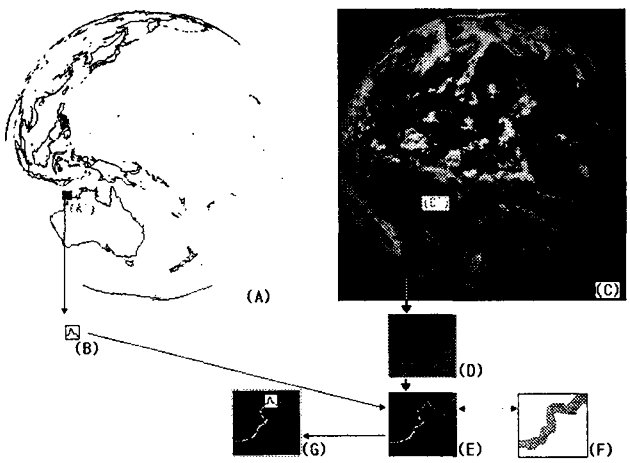
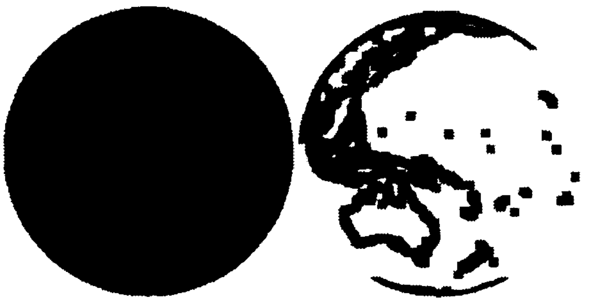


Fig.5. Procedure of the proposed algorithm

4. Experimental Results

1) Simulations with Perspective Plane Images

Fig.6. and Table.2 show a comparison of the calculation time for each image size. In Fig.6, the black areas needed calculations of correlation matrix, so the proposed algorithm (B) has a smaller calculation time than conventional ones. We can see in Table.2 that the calculation time is reduced to 86.17% at 1000x1000 size Image. Fig.7. is the reducing time graph of Table.2.



(A) (B)
Fig.6. Comparison of Calculation times
(A) Conventional (B) proposed

Table.2. Comparisons of calc. time for images size

Image Size [pixels]	No. of Calc. [times]		Reducing Ratio [%]
	Proposed	Conventional	
100 * 100	5,272	7,780	32.24
200 * 200	13,416	31,164	56.95
300 * 300	23,430	70,271	66.66
400 * 400	34,407	125,126	72.52
500 * 500	45,626	195,794	76.70
600 * 600	57,609	282,125	79.58
700 * 700	69,919	384,163	81.80
800 * 800	82,686	501,963	83.53
900 * 900	95,422	635,461	84.98
1000 * 1000	108,509	784,700	86.17

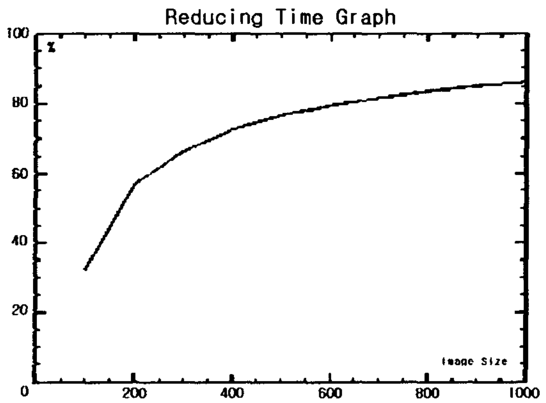


Fig.7. Reducing time graph by the proposed algorithm

2) Simulations with GOES Satellite Images

Fig.8. (A) is a part of the 18978 by 10817 the GOES image and (B) is a Sobel masked image of it.

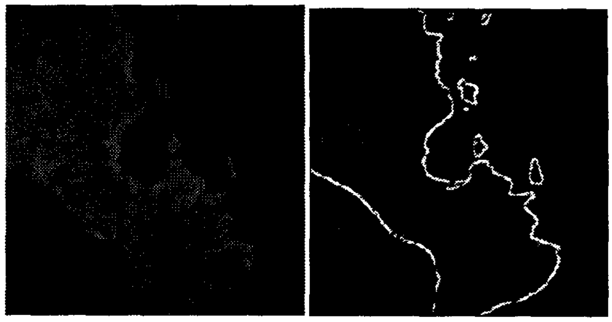


Fig.8. Satellite received (A) and Sobel masked (B) image

Fig.9. is the landmark chip that we want to match in the Fig.8. (A) image, and Fig.10. is a comparison of the calculation time. Fig.10. (A) is the conventional calculative area of calculation of a correlation matrix and (B) is the proposed method. We know that the conventional method requires the full area calculation, but the proposed one needs only a part of the area.

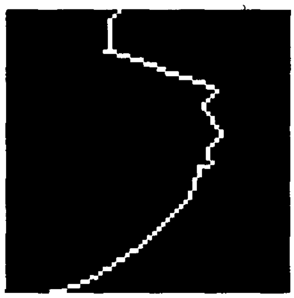
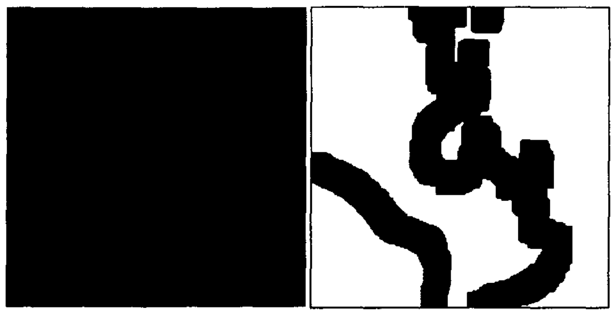


Fig.9. Image of landmark chip



(A) (B)
Fig.10. Area to execute calculation of correlation matrix
(A) Conventional (B) proposed

Fig. 11. is the distribution of values of the correlation matrix between the landmark chip and a part of the satellite image. The matched point has the largest value of correlation in comparison to the others. Fig.12. resulted from the landmark chip overlapping to a part of the satellite image. The result shows that most of the landmark chip is according to the coastline of a part of the satellite image.

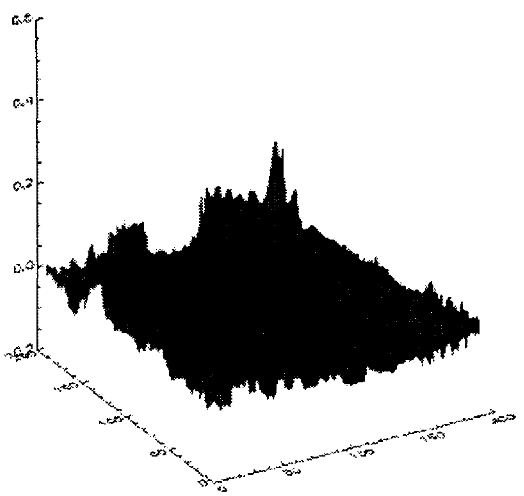


Fig.11. distribution of values of correlation matrix

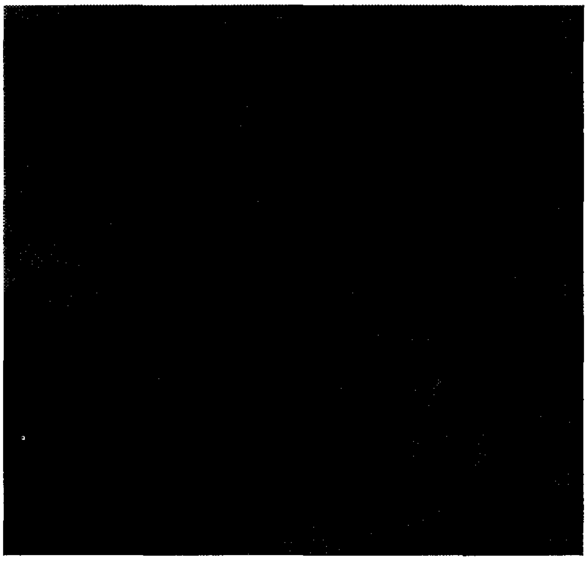


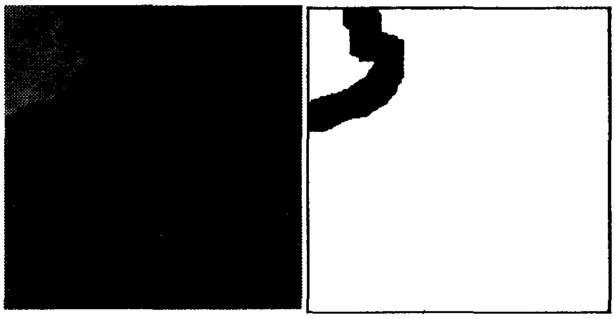
Fig.12. Landmark matched image of satellite image.

Fig.13 and Fig. 14 are another experimental result of landmark matching. Fig. 13 (A) is a landmark matched image of a part of the satellite image and (B) is a MGLI for fast landmark matching. As a part of satellite image has a lot of sea area, the proposed algorithm reduces the calculation time more than 90%. Fig.14. is the distribution of values of the correlation matrix for Fig.13.

5. Conclusions

This paper proposed a fast landmark-matching algorithm, using a MGLI. Instead of calculation of a full-sized correlation matrix, the proposed algorithm uses a MGLI to reference execution of the correlation.

The moving guide-line, using a perspective plane image, can be made quickly but can't apply to the images from the GOES, because the images have incorrect information of line and pixel number. So a binary Sobel-masked image made from the Sobel masked image with a threshold value is used for the generation of a moving guide-line. As a part of the satellite image has a lot of sea area, the proposed algorithm reduces the calculative time more than 90%.



(A) (B)

Fig.13. Landmark matched image (A) and Area to execute of correlation matrix (B)

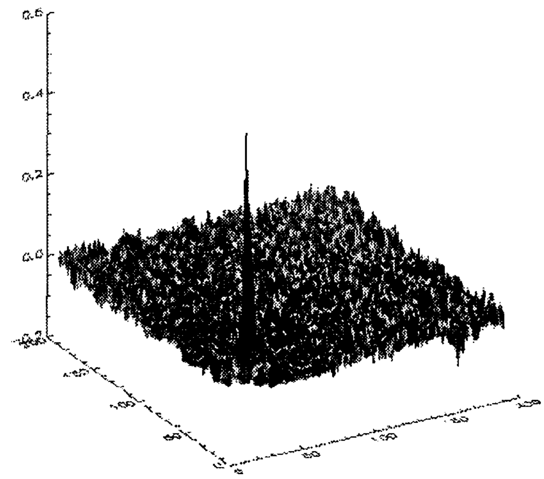


Fig.14. Distribution of values of correlation matrix for Fig.13.

References

[1] Kenichi Hirano, Yasushi Kaibai, and Mikio Takagi, 2000. Residual Error Acquisition for the Precise Geometric Correction of GMS Images, *Proc. ISRS'2000*, Braszil, pp.1506-1511.

[2] Chi-Ho Kang and In-Hoi Goo, 2004. The Global Perspective Plane Image Generation using the GOES-9 Satellite Images, KARI Technical Memo, KOREA.

[3] **The GSHHS Homepage :** http://www.soest.hawaii.edu/wessel/gshhs/gshhs.html

[4] **NOAA Geostationary satellite sever:** http://www.goes.noaa.gov